Agri-Environment Evidence Annual Report 2022

A summary of recently published project reports

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Executive Summary

This report provides summaries of recent projects of the Natural England Agri-environment Evidence Programme, covering the implementation and effectiveness of Agri-environment Scheme (AES) options and agreements, scheme design and delivery, and approaches for AES monitoring. Some projects were constrained by the COVID-19 pandemic.

Effectiveness - Implementation, Advice and Uptake

Several studies assessed delivery of outcomes for specific AES options, considering option design and implementation, but also the role of advice and agreement design. A study of AES options for cultivated or floristically enhanced arable margins showed positive impacts on beneficial invertebrates and rare arable plants. An assessment of Upland Hay Meadow, a rare and declining Priority Habitat, found that AES options had slowed rather than halted declines in habitat condition over an eight-years. A pilot study of organic rotational options suggests benefits for soil quality and soil microbial biodiversity.

Other studies used interviews with agreement holders and Natural England advisers to understand barriers to option effectiveness and uptake. Using satellite data to assess changes in bracken extent on grasslands, bracken control options were found to be effective. However, agreement holder interviews revealed a need to better understand the costs, benefits, and outcomes of different management options. An assessment of three options for protecting Scheduled Monuments and other historic features showed extremely low option uptake, with interviews revealing key barriers were poor fit to farming system, concerns around expectations and compliance, and access to advice. An evaluation of agreements for Lowland Wetland sites under AES on Sites of Special Scientific Interest (SSSIs) revealed significant challenges for option implementation due to small sites and habitat mosaics. Adviser interviews confirmed significant issues for implementing management prescriptions, and that tailoring prescriptions, advice and quality of implementation were key to agreement success. In common with the Upland Hay Meadow study, there was evidence to suggest that habitat maintenance and restoration options had been incorrectly targeted in some instances.

Overall, studies demonstrate that improving the delivery of desired outcomes through AES requires consideration option design and execution, but also the central role of good quality advice in delivering options and creating and implementing agreements.

Scheme Delivery, Design and Climate Change

Achieving benefits from AES at the landscape and national scale are key priorities. The Lowland Wetland study highlighted factors impacting agreements, such as water nutrient enrichment and abstraction, can only be addressed through landscape scale co-operation.

The Countryside Stewardship Facilitation Fund (CSFF) brings farmers and other land managers together to improve delivery of environmental priorities at a landscape scale.

Research showed CSFF groups positively contribute to maintaining, enhancing, and creating Natural Capital at a national and landscape scale, beyond that achieved through individual agreements alone. CSFFs also built strong relationships and trust between group members, improved relationships with a broader range of people and organisations, and improved engagement with institutions. However, negative views of institutions could be re-enforced by vague messaging and evasiveness. The study further suggested that potential impacts of climate change on group priorities needs to be addressed through education and that the benefits of AES to farmers in adapting to and mitigating such impacts need assessing.

Another study used National Character Areas (NCAs) to assess how AES options are delivering against objectives to enhance landscape character, quality, and resilience to climate change. The assessment undertaken for 2018, when compared to the baseline in 2013, showed a decline in the overall number of NCAs in which AES is having a positive impact on landscape character; however, effects were still predominantly positive. Uptake of AES options made a positive contribution to habitat resilience to climate change, but uptake was weakest in the areas where most needed.

A further study of effects of climate change on AES delivery showed that recommended timings of AES management have not changed despite changes in the timing of linked biological events. Further, advisers and agreement holders reported that extreme weather events were already affecting the delivery of agreements and causing costs to farm businesses. A lack of flexibility in AES agreements and processes for making agreement changes were identified as the main barriers to delivering outcomes in the face of climate change.

Overall, these studies suggest AES is having positive effects on landscape scale objectives and that the CSFF approach delivers landscape scale benefits. However, it is recommended that the design of future AES account for the impacts of climate change on delivery and outcomes, address how AES might increase farm scale resilience to climate change, and align work on climate change and landscape objectives.

Approaches to Monitoring

Two projects addressed future approaches to AES monitoring. The first focussed on the capacity of new and developing technologies to deliver future AES monitoring: DNA based monitoring, Ecoacoustics, Earth Observation, Computer Vision and Machine Learning. Expert assessment concluded these technologies would offer benefits if deployed alongside existing monitoring techniques. However, it remains crucial that all monitoring programmes adopt suitable sampling strategies and designs with appropriate statistical power to detect effects. The second project used preliminary data from a project designed to detect effects of AES at local and landscape scales for birds and pollinating insects, to identify if data from citizen science projects produced similar findings and whether there was value in combining the two types of data. Citizen science datasets showed very limited success, highlighting the importance of collecting datasets specifically designed to detect the effects of AES.

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Table of Abbreviations

Phrase	Acronym
Agri-environment Scheme(s)	AES
Citizen Science	CitSci
Countryside Stewardship	CS
Countryside Stewardship Facilitation Fund	CSFF
Earth Observation	EO
Entry Level Stewardship	ELS
Environmental Stewardship	ES
Environmentally Sensitive Area Scheme	ESA
Higher Level Stewardship	HLS
Indicators of Success	IoS
Landscape-scale species monitoring of AES project	LandSpAES
National Character Area	NCA
Natural Capital Indicators	NCIs
Scheduled Monuments	SMs
Site(s) of Special Scientific Interest	SSSI(s)
Upland Hey Meadows	UHM

Background – Agri-environment Schemes in England

Agri-Environment Schemes (AES) encourage farmers and other landowners to protect and enhance the environment on their land by paying them for the provision of environmental services, including the protection of historic features and landscape character. Each scheme offers a range of management options to deliver target outcomes for specific features. Schemes also include a range of one-off capital items which can be used to support management options or deliver their own environmental outcomes. Prescriptions set out the management that must or must not be carried out for each option, and Indicators of Success (IoS) describe what success will look like. The AES referenced in this report are:

- Environmental Stewardship (ES) - open to applications between 2005 and 2014, it consisted of:
    - Entry Level Stewardship (ELS) aiming for high coverage of basic options;
    - Organic Entry Level Stewardship (OELS);
    - Uplands Entry Level Stewardship (UELS); and
    - Higher Level Stewardship (HLS) with more demanding options targeted to features of high environmental value.
- New Countryside Stewardship (CS) – the current AES for England. The first agreements started 1st Jan 2016. Like ES, the scheme consists of two main tiers, a Mid-Tier (MT) and a Higher Tier (HT), however CS also consists of Wildlife Offers (simplified, focussed forms of MT agreements), capital grants (for water quality, air quality, and boundaries, trees and orchards), historic buildings grants, woodland support grants and CS Facilitation Fund.
- The Environmentally Sensitive Areas scheme (ESA), introduced in 1987 to offer incentives to encourage farmers to adopt agricultural practices which would safeguard and enhance parts of the country of particularly high landscape, wildlife or historic value. The scheme was superseded by ES in 2005.

The Agri-Environment Evidence Programme

The Agri-Environment Evidence Programme seeks to monitor and evaluate existing AES, including Countryside Stewardship and Environmental Stewardship. The programme is delivered by Natural England on behalf of Defra, with input from the staff across Defra, the Forestry Commission, Environment Agency and Historic England. Natural England's scheme monitoring work focuses on terrestrial habitats, while that carried out by the Environment Agency includes freshwater habitats and resource protection.

The programme delivers evidence to:

- Evaluate the delivery of AES and their effectiveness in achieving their intended policy objectives.

- Inform current and future agri-environment policy, scheme delivery and development.
- Fulfil domestic reporting requirements.

Purpose of this Report

This report summarises findings from projects in Natural England's Agri-Environment Evidence Programme, completed during 2020 and 2021. Natural England works with Defra to understand these findings and incorporate them into AES development and operational delivery. Key messages are shared internally to inform Natural England staff and help ensure the organisation remains evidence based. This report is also intended to be shared with key partners who contribute to and have an interest in the performance of AES.

Each project referenced in this report has a unique code which is used to identify it. A list of the project codes, their titles and links to the reports are below:

LM0471 - Evaluation of Cultivated Margin Option Effectiveness and Exploration of their Natural Capital

LM0494 - Long-term Impacts of Agri-Environment Management Including Sward Enhancement Interventions on Upland Hay Meadows

LM0495 - Environmental Impact of Agri-Environment Support for Organic Farming

LM04118 – Long-Term Effectiveness of AES Funded Bracken Control

LM04116 - Effectiveness of Historic Environment Options within the Countryside Stewardship Scheme

LM04114 - An Evaluation of Factors Inhibiting or Masking the Progress to Favourable Condition of Wetland SSSIs in AES

LM0484 - Assessment of the Adaptive Capacity of Agri-Environment Schemes to Respond to the Impacts of Climate Change

LM0483 - Monitoring the Impact of Stewardship on Landscape Character, Quality and Resilience phases 1 and 2

LM04101 - CS Facilitation Fund Phase 3: Final Report

LM04108 - Developing Technologies for Agri-Environment Monitoring

LM04109 - Modelling Landscape-Scale Species Response to AES

Study Summaries

Options and Agreements: Effectiveness, Implementation, Advice and Uptake

LM0471: Cultivated Margin Options: Effectiveness for Rare Arable Plants, Pollinators and Natural Enemies

Uncropped cultivated margins were first introduced in 1991, for conserving rare arable plants. They also provide conditions for common annual plants and a foraging resource for farm wildlife, particularly pollinating insects. Cultivated margins may be rotated around a farm each year to avoid the build-up of undesirable plant species. In 2005, floristically enhanced grass margins were added to ES to explicitly provide foraging resources for pollinators and wild birds. Floristically enhanced margins can be established through sowing and re-sowing of seed mixes, but the option allows existing plots to be used without re-sowing. LM0471 evaluated the importance of management factors for both options in determining outcomes for rare arable plants, pollinating insects (bees and hoverflies), and predators and parasites of pests (natural enemies, focussing on beetles and parasitic wasps). Thirty cultivated margins and thirty floristically enhanced margins were assessed over two years.

The study concludes that cultivated margins are functioning as they were originally conceived by providing space for rare arable plants on farmland. Rare plants showed little association with environmental variables, being primarily associated with chalky or sandy soils. However, 'problem' plant species which can suppress rare species had high coverage in most cultivated margins. Cultivated margins also supported a diverse community of beneficial insects with a high abundance of natural enemies and a wide range of pollinating insects visiting flowers. Cultivation through ploughing was found to have a negative effect on the abundance of natural enemies and pollinators, and specifically the presence of solitary bees (species which nest individually, not in colonies like bumblebees or honeybees) visiting flowers. This is likely because ploughing destroys insect nesting sites and changes plant communities. Rotational margins also had fewer flower heads and so attracted fewer bees.

Floristically enhanced margins supported diverse communities of both natural enemies and pollinating insects. Sown margins had more flowers, and so were found to have increased activity for bees and hoverflies compared to unsown margins. Age since establishment was the most important factor influencing vegetation characteristics – recently established margins had higher frequencies of species typical of cultivated arable land, where older margins were more dominated by grass and had fewer flowers.

The study concludes that cultivated and floristically enhanced margins have the potential to promote populations of rare arable plants and beneficial invertebrates. Suggestions to improve outcomes include: **1)** Minimum tillage when establishing margins to support a range of beneficial invertebrates, but this may not be of benefit to the plant species; **2)** Consider promoting a range of perennial plant species favoured by pollinating insects, including permitting them as part of a sown flower mixes; **3)** Ploughing may be appropriate for managing problem grasses, but grass specific herbicides would be less harmful to invertebrates and; **4)** Permitting the selective application of herbicides may also be more effective in controlling invasive plants.

LM0494: Quantifying the Long-Term Impact of AES management on Upland Hay Meadows

Upland Hay Meadow (UHM) is a rare and declining habitat in the UK with less than 1000 hectares remaining, concentrated in the North Pennines and Yorkshire Dales. A Priority Habitat for action under Biodiversity 2020 (Section 41 of NERC Act 2006), it is also included in Annex 1 of the EU Habitats Directive as a habitat of Europe wide conservation concern.

LM0494 updated an assessment of the impacts of AES on UHM, resurveying condition on sites currently managed under HLS or CS surveyed prior to 2013. Ninety five of 103 sites under HLS or CS options for habitat restoration or maintenance were resurveyed. A further 50 restoration sites were used to assess the impacts of enhancement through a range of techniques; adding green hay, harvested seed, purchased seed or plug plants. Eighteen non-agreement control sites were also assessed, 15 of which had been managed under ESA but not HLS or CS.

Status of the sites was assessed using two approaches:

1) The National Vegetation Classification (NVC): UHM is classified as MG3 (sweet vernal-grass - wood cranesbill grassland), with some meadows also supporting MG8 (crested dog's-tail - marsh marigold) in wetter areas. MG6b or MG7 represent degraded stands.

2) Criteria and thresholds for UHM priority grassland (G09) as defined by the ES Farm Environment Plan (FEP) and CS Baseline Evaluation of Higher Tier Agreements (BEHTA). Stands are classified as Favourable (G09-A), Unfavourable (G09-B), Semi-improved grassland (G02-A or B) or improved grassland (G01).

For the core resurvey sites, vegetation recognisable as MG3 and MG8 was found in only 25% and 33% of stands respectively, with the greatest proportion of stands being classed as MG6b – degraded stands. When assessed against the criteria for G09, 45% of the core sample were classed as Favourable, 34% Unfavourable and 19% were not a priority grassland type. Fifty percent of sites under maintenance management were in Favourable condition, compared to 42% of sites under restoration management. The authors suggest that option targeting may have been inappropriate given 49% of sites under maintenance options were Unfavourable, and sites being maintained should be in Favourable condition. Sites in Favourable condition were associated with low available phosphate, higher nitrogen levels, grazing by traditional cattle or sheep breeds, and cutting for hay determined by seasonal conditions rather than earliest possible date.

Seventy nine percent of control sites were classed as MG6b or MG7, with a few being MG3 or MG8. Eighty two percent of enhanced restoration sites were classed as MG6b, though a lack of Favourable condition among these sites may be because they had a poorer starting condition compared to non-enhanced restoration sites. The re-establishment of MG3 associated species did not occur in enhanced meadows, but there was an increase in a restricted suite of positive indicator species over time.

There was a decline in measures of species richness and numbers of positive indicator species from 1987 – 2020. Of the 95 core sites, 69% of sites in a Favourable condition in 2012 remained so in 2020 and declines in condition were greatest for sites under restoration management. G09 indicator species were positively associated with low phosphate and potassium levels, and with cutting for field-dried hay rather than haylage (grass cut younger and not left out to dry for as long as grass for hay). The addition of nitrogen, phosphorus, potassium fertiliser was detrimental to site condition.

The overall picture is one of declining species richness and little change in the proportion of sites falling under Favourable and Unfavourable condition, despite continued HLS management. This must be interpreted against a backdrop of changes in farming practices and environmental conditions. AES management may have a positive impact in slowing, but not halting, deterioration resulting from agricultural intensification. Small or extensively managed holdings are essential to the existence of UHM, managed holistically to reduce pressures on the meadows and other habitats. The report provides several recommendations including earlier dates for stopping grazing, later cutting dates, additional payments to support later cutting and traditional breed grazing, limiting farmyard manure application and supplementary payments for adding plug plants and green hay.

LM0495: Scoping the Impacts of Organic Management on Soil Properties, Soil Biota and Landscape Structure

The pilot study LM0495 assessed the environmental and landscape character impacts of the CS organic option OT3 - Organic Management of Rotational Land. Rotational land involves planting of different crops sequentially on the same plot of land to improve soil health, optimize nutrients in the soil, and combat pest and weed pressure. Effects on soil quality and earthworm numbers were tested by comparing 15 organic fields (under organic management for 10 – 15 years) with 15 paired conventional fields of similar soil type. Management condition relating to water course protection, derived from assessments of erosion, vehicle use, grazing pressure and vegetation residue cover were also compared. In addition, DNA metabarcoding was used to compare the communities of bacteria, fungi, nematodes, worms, and other invertebrates between sites. The project also tested whether landscapes with organic management are more structurally complex than those managed conventionally using eight case studies. Landscape structure was assessed using parameters related to parcel number and size, area-perimeter ratio, edge density and habitat diversity.

Soils in organic fields were found to have significantly higher organic matter and extractable magnesium, but there was no significant difference between organic and conventional fields for other chemical measures, soil bulk density, structural measures, or earthworm counts. Vegetation / residue cover was also significantly higher for organic sites, though this may relate to differences in cropping system.

Analysis of DNA metabarcoding data was constrained by small samples sizes, but organic soils were characterised by a more even relative abundance of bacterial taxonomic groups; suggesting the bacterial community in conventional soils was less diverse. The analysis identified several bacterial taxonomic groups that could be acting as biomarkers for organic soil, but this requires further study. The comparison of landscape structure across the eight case studies indicated that there were no significant differences in structure between 1km squares containing organic options and those that did not.

Given this project was preliminary it provides suggestions for improving protocols for fieldwork and desk-based aspects for larger scale monitoring of the effects of organic management on soils and landscape structure.

LM04118: The Long-Term Effectiveness of Bracken Control under AES in England

Bracken management options (chemical or mechanical) have featured in all AES schemes, as bracken can cause damage to priority habitats, grazing land and archaeological features. Climate change and more natural methods of land management have the potential to increase the dominance of bracken in the English countryside. LM04118 used remote sensing to assess the effectiveness of options for bracken control, along with land manager interviews to gather evidence regarding approach and the perceived effectiveness of bracken control.

For 134 parcels containing relevant bracken management options, remote sensing data from Landsat and Sentinel 2 satellites were used to compare bracken coverage from a baseline period of 2014 – 2016 against ‘revisits’ in 2018 - 2020. Most parcels were found to have bracken coverage that had decreased since baseline (57) or bracken coverage which had remained stable (52); suggesting that bracken control and follow up options are reducing or limiting bracken expansion. Data on the location of option placement within parcels is not available, therefore the analysis focussed only on parcels with option coverage greater than 90% of the parcel area. Limited sample size and a geographic clustering of parcels meant that a robust analysis of the impacts of environmental variables was not possible.

Interviews with 171 land managers suggested that advice on bracken management was important to agreement holders, but that land managers were not convinced of AES effectiveness in the first year. Managers would often undertake management more frequently than prescribed under options, for example mechanical options were often deployed annually whilst the agreement only paid for 2 – 3 years within a 10-year period. Three of four agreement case studies also suggested that it took multiple years before bracken cover was significantly reduced. Grazing options were also used for three quarters of agreements, but perceptions of effectiveness were mixed.

Overall results suggest that the management of bracken under AES is beneficial for reducing the impact of bracken on grasslands, but data on the spatial extent of options would allow for a more robust analysis. Further study into the effectiveness of grazing strategies for bracken management is recommended, as is an examination of the costs of different approaches to help management options be more realistic in terms of time resource required. It is also suggested that knowledge exchange hubs for the sharing of local information between agreement holders would be beneficial and could be used to test the outcomes of different approaches.

LM04116: The Effectiveness of Historic Environment Options HS3, HS4 and HS9

Under CS it is compulsory to include Scheduled Monuments (SMs) in agreements; SMs in good condition are covered by maintenance options and those in poor condition by restoration options, with capital items where necessary. Non-designated historic features are also eligible for Higher Tier agreements for options at the discretion of the local adviser.

LM04116 evaluated the uptake of three options addressing two of the biggest threats to SMs: cultivation and scrub encroachment. The options were: HS3 Reduced-depth, non-inversion cultivation on historic and archaeological features; HS4 Scrub control on historic and archaeological features; and HS9 Restricted depth crop establishment to protect archaeology under an arable rotation.

The area under options with SMs and undesignated sites at risk from cultivation or scrub was quantified, whilst surveys (25) and follow up interviews (12) investigated land managers motivations where they had omitted the three options from their CS agreements. Interviews with 34 agreement holders whose agreements contained one of the three options addressed their motivations. A field survey of 15 farms applying option HS9 was used to assess option effectiveness.

A total of 6,678ha of land was identified as being under the three options, with HS3 covering c.88%, HS9 c.11% and HS4 c.2%. Analysis estimated SMs at risk from cultivation covered 3,117ha, with just 117 ha under options HS3 and HS9. For scrub encroachment the area of SMs at risk was 736 ha, with only 9 ha under option HS4. For undesignated sites at risk from cultivation, all three options together covered 1,527 ha of sites (95% of which is HS9), <1% of total area.

Surveys and interviews suggested many farmers are unaware of historic features on their land and / or opportunities to receive payments for these under CS. Primary reasons for lack of option uptake were concerns relating to the commitments involved, restrictions on future land use, and risks from liability for feature damage and non-compliance. Additionally, there was a view that it was uneconomic given payment rates, income loss due to reduced production and poor fit with farming system. Agreement holder interviews suggested option uptake was mainly related to fit with farming system, scheme applicability and economic benefits. For example, HS3 respondents were already practicing shallow cultivation or moving towards minimum tillage and HS4 presented opportunities to receive payments for unproductive land. Access to knowledge and advice were identified as important for uptake.

The in-field assessments of HS9 found that unclear guidance could lead to options being applied over just the area of the feature within a land parcel, when options can be applied over the entire land parcel. Further, HS3 and HS9 should not be applied to fields where soil loss is a problem, but 14 of 27 parcels surveyed had a moderate or high risk of soil erosion or run-off.

Recommendations include: **1)** Facilitating higher uptake of the three options; **2)** Reviewing eligibility criteria for the three options and non-designated sites in CS Mid-Tier; **3)** Improving awareness of historic features amongst farmers; **4)** Considering higher payments for assets found on productive land, and; **5)** Improving the clarity and accessibility of advice and guidance both through Historic Environment Farm Environment Records and CS.

LM04114: Factors inhibiting or masking progress of favourable condition wetland SSSIs under AES.

Lowland wetlands support high biodiversity, form major carbon stores and play an important role in the water cycle. Many lowland wetlands were destroyed or damaged over the last century, with the best remaining sites protected through designation as Sites of Special Scientific Interest (SSSIs). Some wetland SSSIs are managed under AES, but there has been little improvement in their condition. LM04114 evaluated the set up and implementation for AES agreements on 40 wetland SSSI units, including the two priority habitats, Lowland Fen and/or Purple Moor Grass and Rush Pastures.

Agreements were evaluated on choice of options, supplements and capital items in relation to the habitat and its condition. An assessment of ecohydrological factors focussed on threats such as groundwater abstraction, drainage, and nutrient enrichment from the catchment. Information was collated from documentation, national datasets and questionnaires for Natural England advisers and agreement holders.

Most units were under the Fen or species-rich grassland maintenance or restoration options, with cutting and/or grazing supplements and capital items associated with vegetation management (57%) and water control (25%). A total of 67% of units were considered in Unfavourable condition, based on Common Standards Monitoring assessments (82% ‘Recovering’) and 33% were considered as Favourable.

Agreement set up: Option choice was broadly appropriate, but restoration and maintenance options could be applied inappropriately. Option choice was complicated because sites have mosaics of different habitats or the same habitat in different conditions. Further, some wetlands were overlooked because they covered only a small proportion of the overall SSSI unit, or conversely options were prescribed to a larger area than appropriate. Agreement holder interviews suggested personal knowledge of sites, site condition assessments and aftercare reports from previous AES agreements were important sources of information. Most advisers and agreement holders reported that agreement holders received sufficient information at the start of their agreement, but advisers were less positive about agreement holders receiving appropriate support throughout the agreement.

Prescriptions and Indicators of Success (IoS): IoS are developed by Natural England advisers at the start of an agreement, reflecting baseline site condition and potential for change. Grazing was commonly prescribed, but the mosaic nature of wetlands made it challenging to graze habitats with different requirements separately. Prescriptions for hydrology were included for most Fen options for HLS. Prescriptions and IoS under maintenance or restoration showed little differentiation, suggesting poor targeting or limited scope to change management within options. IoS quality was variable for habitat and biodiversity outcomes; sometimes lacking for small wetland units and focusing on habitat structure for individual species (e.g. birds) rather than species composition. IoS for hydrological aspects were vague (e.g. ‘squelchy underfoot’) and supplements for managing water levels were relatively low (25%) considering problems arounds SSSI hydrology were the most common. Agreement holders felt that prescriptions and IoS were at least partially appropriate, and most reported a good level of understanding of objectives and IoS.

Implementation and outcomes: There was some evidence of scrub expansion being recorded where scrub management was prescribed. The study suggests low payment rates for Fen habitat options, relative to other core options, and for cutting and grazing supplements can combine with small unit size to affect the quality of implementation. Over a third of advisers reported no issues with implementation, but others reported significant problems relating to cutting and grazing, physical vegetation control and water level management. Factors considered by advisers to be most important to promoting or limiting agreement success were the tailoring of management prescriptions to sites, agreement holders receiving sufficient and quality advice, and how well management prescriptions were implemented.

The study concluded wetland sites present significant challenges to successful delivery of AES agreements including selecting appropriate options and prescriptions, grazing for habitat mosaics and difficulties presented by wetland in maintaining animal welfare and operating machinery. The lack of improvement in the condition of wetland sites suggests that managing change through schemes is not sufficiently ambitious. However, the likely root causes of damage, such as water abstraction or nutrient enrichment from the catchment, are often partly due to off-site activities and cannot be addressed by individual AES agreements alone. The authors suggest that the most important factor required to improve outcomes is facilitating collaboration at the landscape scale.

Scheme Delivery and Design

LM04101 Assessing the Natural Capital and Social Capital Benefits of the Countryside Stewardship Facilitation Fund

The Countryside Stewardship Facilitation Fund (CSFF) provides funding at the landscape scale for individuals or organisations to bring farmers, foresters and other land managers together to increase their knowledge and awareness and align delivery with the environmental priorities for the area. CSFF funds groups of farmers/land managers, with and without CS agreements, working together as a local partnership, with a paid facilitator coordinating training and advice.

LM04101 evaluated the performance of CSFF with reference to Natural Capital (NC) and social indicators, focussing on nature recovery and ecological restoration. This third phase of evaluation had four work packages:

1) Further developing the CSFF monitoring and evaluation framework.
2) Using Natural Capital Indicators (NCIs) to assess how CSFF groups have delivered against their ecological goals, drawing upon 98 CSFF groups and five case study CSFF groups.
3) Using 23 interviews from case study groups (1 adviser and 3-4 members) and 20 interviews with facilitators to assess benefits to social outcomes and behaviour change.
4) Assessing additional resources and contributions achieved through 25 interviews with CSFF group facilitators.

LM04101 assessed the contribution CSFF groups are making to the maintenance, creation, and enhancement of NC through the application of CS options and their impacts on NCIs. The conclusion was that CSFF groups are without question positively contributing to maintaining, enhancing, and creating NC, with the primary mechanism being CS agreements. Field surveys of case study CSFF groups found good evidence that CSFF group priorities and option choices were aligned with identified land management issues and priorities as defined by the NCA in which they were found. The second phase of evaluation (Jones et al. 2020, LM0479) additionally showed this was enhanced compared to agreements outside CSFF groups. Together this suggests that CSFF groups deliver additional positive effects on NC beyond that which would be achieved by individual holdings in isolation.

Interviews showed that CSFFs promoted relationships between members based on trust and reciprocity (increased **Bonding Social Capital**). **Bridging social capital** is social connection between individuals who have dissimilar socioeconomic and other characteristics. This was improved, as members engaged and built relationships with a broader range of people and organisations (e.g., ecologists, wildlife organisations, members of the public), leading in turn to increased knowledge and environmental activity. **Linking social capital** describes networks of people characterised by power differences, in this case relating to farmers interacting with institutions. Some facilitators reported changes in engagement with agency representatives through meeting attendance, and group involvement in Defra’s Environmental Land Management (ELM) consultations was cited as particularly effective in strengthening relationships and giving members a voice. However, consistency in persons attending meetings was seen as crucial to building trust, and negative views of institutions were re-enforced by unclear messaging and evasiveness on future policy. Facilitators and farmers also suggested that being in a CSFF had altered members willingness to change and facilitated capacity to change through access to advice and training.

Sixteen facilitators highlighted their CSFF had accessed additional funding from other sources, from companies, Non-Governmental Organisations (NGOs), charities and government departments. Five reported contributions made up a moderate – high proportion of the group's resources, whilst five reported it to be low. Ten stated that the influence of this funding on outputs achieved was high – very high, and eight stated that the proportion of outcomes achieved by the group relating to these additional funds were moderate – high.

The project provides some strategic suggestions for possible next steps for CSFF and future AES:

Further developing and integrating the NC approach:

- **Increase uptake:** Increase CSFF members entering AES and identify and quantify local land management undertaken outside of AES and develop ways to measure this.
- **Baselining NC at agreement level:** Creating a baseline of NC asset stocks, including asset condition, for each holding within a CSFF to measure gains and aid decisions.
- **Collect spatially explicit data:** Collect data on the location and landscape context of actions to aid in NC assessments and understanding ecological connectivity.
- **Inbuilt NC assessments:** Integrated NC assessments into the creation of Farm Environment Plans or similar mapping efforts when holdings enter AES.

Improving outcomes delivered by CSFF and future AES schemes:

- **Funding:** Funding for 5 years as a minimum is suggested for building necessary relationships and delivering outcomes.
- **Facilitators:** Funding skilled facilitators is needed, and facilitators should be given opportunities to regularly share their experiences and to develop their skills. Some funding for one-to-one advice to support members should also be considered.
- **Group members:** Encourage members to influence group activities and contribute their own ideas and use management tools to energise groups and sustain momentum.
- **Encouraging uptake of CS:** Only 43% of group members had a CS agreement, so CSFF groups should encourage wider uptake. It is suggested that streamlining AES prescriptions and increasing flexibility in AES so as they align with the environmental goals of the group could improve uptake. Reporting to groups on the monitoring and evaluation of their environmental outcomes may also sustain and reinforce pro environmental behaviours.
- **A group size of 15 - 20** should be considered optimum as smaller groups risk low attendance and larger groups can hinder the open and trusting exchange of information.

- **Climate change:** Education on climate change and how AES options might help farmers mitigate and adapt to its effects should be prioritised, as it was identified as threat to all group priorities.
- **Measuring change:** A baseline survey of attitudes, knowledge and behaviours should be considered for new groups/members to determine if groups facilitate change over time.

LM0483: What have been the landscape effects of Agri-environment Schemes at the scale of National Character Areas?

LM0483 assessed the effectiveness of AES (CS and remaining ES) in maintaining and enhancing landscape character, quality and resilience to climate change. The project provides an update on research undertaken in 2013 (LM0429).

Phase one updated the evidence and database for assessing the landscape effects of AES in each of the 159 National Character Areas (NCAs) in England. Phase two explored the effects of options on landscape character in NCAs, the contribution of AES to the creation of landscapes resilient to climate change and the effects of AES within nationally designated landscapes. Landscape character can be defined as a distinct and recognisable pattern of elements, or characteristics, in the landscape that make one landscape different from another, rather than better or worse (Tudor, 2014).

The assessment was structured against eight landscape themes: woodlands and tree cover, field patterns and boundary types, agricultural land use, traditional farm buildings, historic environment (including parkland), semi-natural habitats, coast, and water management. Within each theme, landscape effects were assessed against objectives associated with the key landscape characteristics of each NCA, informed by indicators linked to the relevant AES options that benefit the landscape. Judgements on landscape effects were assisted by use of thresholds expressed as the percentage of AES uptake (of the stock of landscape feature(s) that the AES options are affecting) at which positive change in the landscape would start to be noticeable. The sum of the results across all themes provides the overall landscape assessment for each NCA.

Whilst there was a decline in the number of NCAs where AES options were having a positive effect on landscape character (Figure 1), the overall picture in 2018 was still largely positive. Whilst at a theme level, ‘field patterns and boundaries’ showed a decline in NCAs where positive or strongly positive landscape impacts are being achieved, ‘semi-natural habitats’ remains the theme where the most strongly positive and positive landscape impacts are being achieved.

Phase two included an assessment of AES options effectiveness for:

a) Conserving and enhancing landscape character: Landscape objectives with options for hedgerows, species-rich grassland, archaeological features, and rough pasture were assessed as having the most widespread positive impact on landscape character. Objectives showing less positive impacts were those with options for enhancing diversity of arable landscapes, management and restoration of traditional water meadows, new coastal habitat creation, re-wetting areas of blanket bog, mires and flushes, and restoration of historic farm buildings.

b) Landscape resilience to climate change: The extent to which AES options might help make landscapes more resilient or support adaptation to climate conditions was evaluated by considering the contribution of the eight landscape themes to nine objectives for climate change adaptation. Overall, the analysis suggests that in many cases AES options that are making a positive contribution to landscape character are also helping to deliver resilient landscapes and wildlife habitats. However, spatial data on option uptake suggests contributions are not always strongest in those areas likely to experience the greatest climate change in the future.

c) Impacts within protected landscapes: 34 Areas of Outstanding Natural Beauty (AONBs), 9 National Parks and the Broads Authority in England were assessed (though Norfolk Broads has since been given National Parks status). The assessment suggests that AES uptake is having a strongly positive effect on landscape character in 12 protected landscapes, a positive effect on 26 and a neutral effect on six. Positive effects of AES options on landscape character occurred much more frequently in protected landscapes than other areas of England and positive impacts were less common in NCAs that do not overlap with any protected areas. However, results should be interpreted with caution because landscapes may be assessed as neutral due to their large size, or high levels of landscape feature stocks.

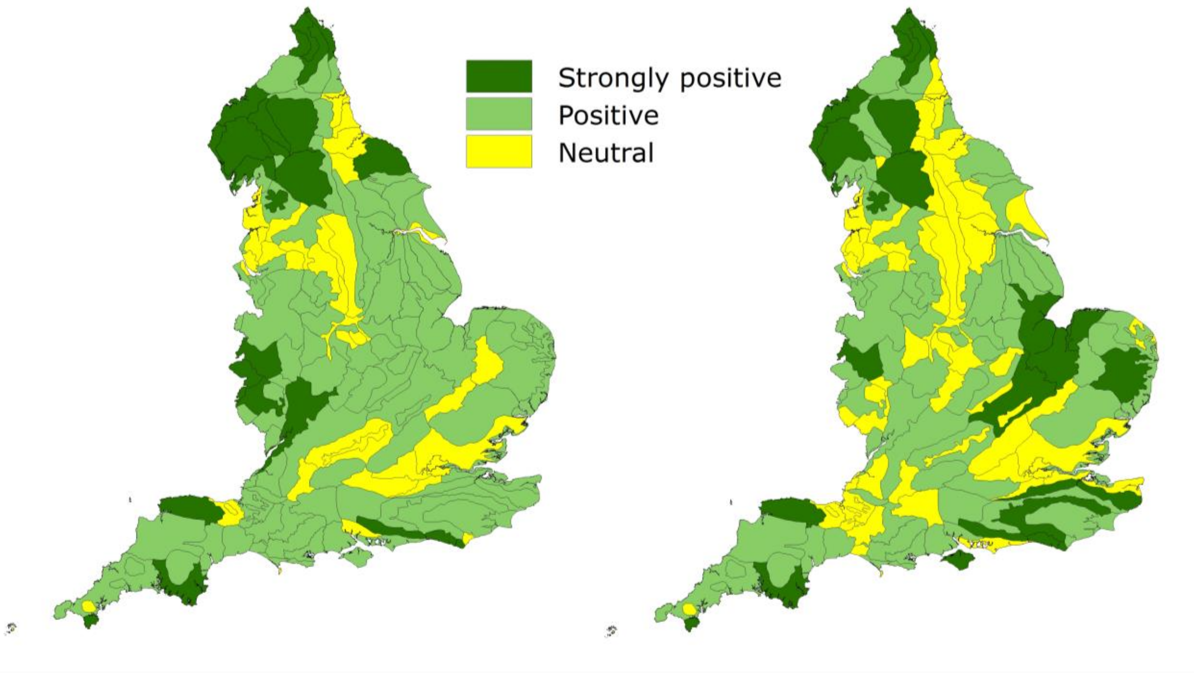

Figure 1: The overall effects of AES on landscape character by NCA in 2013 (left) and 2018 (right), showing a 17 percent reduction in NCAs in which AES options have had either a positive or strongly positive impact on landscape character, and a corresponding increase in NCAs where AES options were assessed as having a neutral effect. Reproduced from Mason, D., Roberts, V., and Grant, M. LM0483 (2020). © Natural England.

Based on the findings of this research, several recommendations are made with regards to future AES including: **1)** Options supporting landscape character objectives with the greatest positive effect should be maintained; **2)** Landscape objectives assessed as not meeting thresholds need improved targeting or incentivised uptake; **3)** Landscape and climate objectives should be closely aligned to ensure the delivery of integrated outcomes; **4)** AES should take a flexible approach to recognise England's variety of landscapes (protected and unprotected) and also support their contribution to the Nature Recovery Network and; **5)** Monitoring of the effectiveness of AES for conserving and enhancing landscapes should continue in the future as a strong component of Scheme monitoring and evaluation.

LM0484: The adaptive capacity of AES to respond to climate change

Climate change presents challenges to AES through gradual change in the timing of ecological events and increases in the severity and frequency of extreme weather events. LM0484 asked two questions:

1) Is there evidence that climate change impacts affect the ability of agreement holders to deliver AES prescriptions and IoS?

2) Is the operation of AES sufficiently flexible to ensure it can accommodate changes to the natural environment because of climate change, without adverse impacts on desired environmental outcomes?

The study assessed past and projected trends in springtime events (e.g. budburst) from 30 indicators, mapping them against the dates set out for operations in 30 AES options (e.g. cutting vegetation). Whilst there has been a clear change in the timing of biological events over the past 30 years, there have been no changes in the timing of prescribed AES management. For example, cutting and grazing periods overlap with the emergence of insect species.

An online survey (420 responses) and telephone interviews (28) of agreement holders and (9) advisers in areas known to have experienced extreme weather events were used to understand impacts on farming and scheme operations. This focussed on three case study areas with recent experience of extreme weather events: West Anglia (drought); Somerset (drought, flooding); and Cumbria (flooding). Ninety percent of survey respondents had been impacted by extreme weather and over a third of these reported this as severe on at least one occasion in last 5 years. The top factors reported were extreme heat (70%), extreme wet (65%), unseasonal weather and timing (68%) and drought (57%). Of the 331 respondents with AES agreements, 149 said weather variability had affected their ability to deliver AES, the top impacts being options not establishing and high levels of pests and weeds. Of those respondents reporting impacts of extreme weather on their agreement 30% (44) reported an additional large cost to the farm business, and 60% a small cost. A lack of flexibility in AES agreements and complex administration for adjustments were perceived as barriers to delivering environmental outcomes. However, in a fifth of cases agreement holders identified AES options as having made their holding more resilient to extreme weather events.

Interviews showed agreement holders and advisers reported earlier springs and warmer, wetter winters and impacts of extreme weather events on farm business and AES agreements. Drought and heat had effects across England and on different farming systems, but flooding and wet extreme events were focussed in the North and West. Soil type and management were key factors in reducing the impacts of extreme weather, improving resilience to drought and reduced surface run off. A lack of flexibility in AES options again emerged as a barrier for achieving outcomes, in particular the process of requesting a change by derogation or Minor Temporary Adjustments (MTAs). Agreement holders and advisers agreed that making minor decisions at a more local level would deliver more effective outcomes. Derogations were seen as appropriate for major changes to agreements, such as a change in location and / or sequencing.

Recommendations regarding the development of future land management schemes include: **1)** Providing guidance and training for agreement holder and advisers around the impacts of climate change and extreme weather events; **2)** Greater flexibility in prescriptions for grazing and the establishment of arable options; **3)** Improving administrative processes around making changes to agreements and; **4)** Delivering minor changes to AES agreements through local advisers.

Approaches to AES monitoring

LM04108 The potential of emerging technologies for AES monitoring

LM04108 explored the potential for Bioacoustics, DNA based monitoring, Earth Observation (EO), Computer Vision and Machine Learning to contribute towards AES monitoring over the next ten years.

Bioacoustics is the study of biological and environmental sounds. There is potential for recording and monitoring specific species or taxonomic groups, as well using acoustic indices of diversity which reflect biodiversity. It is recommended that existing approaches developed for birds and bats are built on for other taxonomic groups. A trial of acoustic indices in a range of AES habitats and landscapes could address how to deploy recorders most effectively in UK contexts and calibrate results with existing sampling methods to determine their effectiveness.

DNA based monitoring uses unique signatures within an organism's DNA to provide data on species presence, community composition and community function. DNA can be acquired by directly sampling organisms or indirectly from traces of DNA left in the environment by organisms (eDNA). DNA approaches can provide data of relevance to AES monitoring; the presence/absence of species, estimates of community composition (species inventories) and diversity, measures of ecosystem function (e.g., measures of the genetic potential for biogeochemical processes) and the identification of trophic interactions and food webs. DNA based approaches can already be used to identify invertebrate species from specimens and it is anticipated that eDNA methods to identify species from DNA water from traps will be operational in 5 years. Mammals and amphibian communities associated with water sources can also be identified from eDNA. Methods for characterising invertebrate, bacterial, fungal and other microbial communities associated soil are also already available.

Earth Observation (EO) covers a vast array of approaches to sensing the environment, including any approach using sensors to detect a signal within parts of the electromagnetic spectrum – attached to satellites, piloted aircraft, remote piloted aircraft or drones. It is recommended that a core set of measures for AES monitoring from satellite or airborne EO are identified to develop a programme for delivery. This programme should involve development of automated analysis processes, collecting reference datasets for algorithm training and validation, continued production of analysis ready data from the Sentinel 1 and Sentinel 2 satellites by Defra, and coordination between the aerial photography (4 year cycle) and airborne lidar (5 year cycle) campaigns to provide temporal matching. Cloud computing capacity to match EO data processing and archiving requirements is needed, along with software to facilitate access and use.

Machine Learning uses algorithms to learn from data without the need for explicit instructions from the user. It can be supervised, whereby inputs and known outputs are combined to produce predictive models, or unsupervised, in that the algorithm takes the inputs and find patterns. This technology can be applied to the other novel technologies to automate processes and combine datasets. However great care is needed if it is informing decisions impacting the lives of those working within the agri-environment sector. Opportunities emerging from machine learning should be continually reviewed and its potential to combine datasets from multiple sources on AES option effectiveness explored.

Computer Vision is a form of supervised machine learning which uses algorithms for the automated classification of images into categories (e.g., of plants or animals into species), or the detection of objects within images. Existing technologies using computer vision which could have applications for AES monitoring are camera traps for insects and mobile phone applications for identifying plant and animal species. Computer vision requires extensive image libraries from which algorithms can be trained to identify objects; quality training datasets are essential to its success. Existing camera traps need to be tested in the field to assess performance and costs/benefits relative to traditional survey methods. The usability of mobile applications to support species identification for AES monitoring also needs be assessed, including use by non-experts.

Expert assessment showed consensus that current AES monitoring fulfils its purpose but could be improved through emerging technologies. AES monitoring could not be delivered solely through emerging technologies, either in the immediate future or the next 10 years, but deployment alongside traditional approaches could deliver elements and novel metrics of biodiversity. New technologies provide information generally broader in scope (spatially, taxonomically, and functionally) than in depth site-based AES monitoring and provide large datasets. Crucially, all monitoring programmes must adopt appropriate survey designs to provide data that are fit for purpose. Specifically, sampling strategies must provide data representative of the target population and power analyses should be used to ensure surveys deliver adequate statistical power to detect effects.

LM04109: Modelling Landscape-scale Species Responses to AES

The Landscape-scale species monitoring of AES project (LandSpAES; LM0465) is assessing the response of mobile organisms (birds, bats, moths, butterflies, bees and hoverflies) to local (1 km) and landscape (3 x3 km) gradients in AES. LM04109 used preliminary data from LandSpAES to explore whether data from Citizen Science (CitSci) Schemes could find similar relationships to those from LandSpAES data and explored whether analyses combining CitSci and LandSpAES datasets was feasible.

Project objectives were to:

1) Assess whether comparability of AES gradient effects between the datasets is improved by adding environmental covariates to account for variation between survey squares.
2) Determine whether relationships between AES gradients and the abundance or species richness of different mobile organisms are similar between datasets.
3) Determine whether integrated approaches can reduce uncertainty in quantifying the impacts of AES gradients at a national scale.

Data for six groups (butterflies, bumblebees, hoverflies, solitary bees, and birds) were used to derive response variables based on abundance and diversity for each. Analyses were undertaken for the same response variables using each dataset, to look at the response to AES gradients whilst accounting for the effects of 28 environmental variables.

The LandSpAES project was designed so local and landscape scale gradients in AES were not correlated, and so their impacts could be understood independently. For CitSci schemes there were correlations between local and landscape scale gradients, and these were so strong for moths that the data could not be included. Correlations between AES gradients and other habitat variables showed these were mostly not confounded.

Modelling the effects of AES gradients separately for each dataset showed relationships with AES gradients were broadly similar between the different datasets for butterflies, bumblebees and solitary bees. For butterflies, there were significant positive relationships between AES gradients and abundance, species richness and diversity. For bumblebees, no significant relationships with AES gradients were found for abundance, species richness or diversity, but the non-significant relationships were broadly similar between the datasets. For solitary bees, only abundance showed similar relationships between datasets. As such, these variables were used for integrated modelling using both datasets. This reduced uncertainty in the results for five of the nine variables taken forward; butterfly abundance and species richness, bumblebee abundance and species richness, and solitary bee abundance.

Overall integrated modelling was not suitable for most variables considered (18) or did not reduce uncertainty (4) and for moths specifically it was not possible to separate AES gradient effects from habitat variables. Whilst successful joint modelling was possible, this was for the minority of CitSci datasets, and as such it cannot be assumed that CitSci datasets would be able to provide evidence for impacts of AES equivalent to that of monitoring specifically designed to detect AES effects. This highlights that to understand the impacts of AES on mobile animals carefully designed monitoring should be used to maximise the detection of AES effects whilst avoiding confounding effects with habitat variables.

Future Evidence Needs

Projects detailed in this report have addressed in part some of the evidence needs identified in previous annual reports (Brown 2020; Oatway 2018; Sykes 2021), such as the use of natural capital and social capital indicators (LM04101), the monitoring of AES on SSSIs (LM04114), research into management for pollinators (LM0471 and LM04109) and the monitoring of options through remote sensing (LM04118). Projects in this report have also identified some specific future research needs:

- Larger scale monitoring of the effects of organic management on soils and landscape structure, with refined methodologies (LM0495).
- Further study into the effectiveness of grazing strategies for bracken management, requiring improved spatial data on bracken extent within parcels for assessing outcomes, and an assessment of costs and benefits of different management approaches to inform options prescription (LM04118).
- Field work to assess actual change in condition of Upland Wetland sites on SSSIs under AES agreements, including the influence of landscape factors and an assessment of the effects of adviser expertise (LM04114).
- A comprehensive review of best practice for AES options in the light of changes to biological events due to climate change and a more in-depth exploration of costs to AES agreements and farm business from extreme weather events (LM0484).
- Monitoring the effectiveness of AES in conserving landscape character, quality and resilience, considering **a)** impacts of options creating new habitats or significant changes to land cover, **b)** monitoring outcomes rather than uptake and **c)** a systematic NCA scale analysis of landscapes to baseline resilience to projected climate change (LM0483).
- Research to assess the contribution new and emerging technologies can make to AES monitoring, and options for their operationalisation (LM04108).

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